

grown into a large, viable facility incorporating scientists at many universities, non-profit research institutes, and private industry research labs. Attachment B shows the network as it existed in December of 1982 and lists the participants. The network is particularly interesting in two ways: (1) It ties together researchers in academic laboratories, industrial research laboratories, and non-profit institutions. (2) It uses three physical communication systems--the telephone system, Telenet (a commercial service), and ARPAnet. Each system provides advantages to certain types of users.

Whether inspired by the CSNET example, driven by their own disciplinary needs, or both, other fields are beginning to move toward establishing similar national networks. For example, the cognitive scientists are reputed to be planning a network, as are the chemists. Further probing would probably uncover other pockets of interest in a variety of disciplines.

DARPA

DARPA is reportedly splitting ARPANET into two parts; one piece (MILNET) to serve as a data communications network for the military community, the other (ARPANET) to continue as a research tool. That split should be complete sometime this year, and it should alleviate much of the concern that has been expressed in the past toward mixing unclassified civilian research use with sensitive military applications of the network.

In addition, DoD has reportedly expressed interest to NSF in divesting themselves of the ARPAnet and letting NSF operate it as a civilian research network.

III. Observations:

Based on this brief analysis, a number of tentative conclusions can be made:

- 1: Substantial support exists in the scientific community (though it is likely not unanimous by any means) for a national computer network. The network would serve two major functions: (1) provide remote access to specialized computational and automated information resources and (2) provide a messaging and conferencing system to facilitate scientific communication.
2. The experience of ARPANET and CSNET suggests that such a network is technologically feasible and scientifically useful.
3. There remain significant issues to be explored. Among them:
 - a. Cost -- No attempt has been made to extrapolate CSNET or ARPANET costs to a system used by the entire scientific community.
 - b. Role of ARPANET -- Would DARPA be willing to transfer ARPANET to NSF, what conditions would entail, and would ARPANET be the best vehicle for a national science network?

- c. Payment -- How would the costs of network operation be assumed, by direct subsidy, by user fees, through funds provided in research grants? Clearly, since usage patterns are affected to some extent by charging schemes, this decision will shape the nature of network use.
- d. Private sector involvement: As of now, no commercial service duplicates the capabilities available through ARPANET, and basic research users may not constitute a large and wealthy enough client base to attract commercial entry. At the same time, commercial entry in the data base communications market is growing rapidly, and the interface between a government network and these private services will have to be explored carefully.
- e. Human interface problems -- Most scientific network use to date has been by scientists who are comfortable with computer and communications technologies. A national network would, hopefully, serve a much broader community of users. A careful assessment of their needs and working patterns needs to be taken into account in the network design.
- f. Network management -- NSF is now considering how to handle the management of CSNET. Since it has grown to be a large and viable activity with likelihood of long life, demands on NSF staff time and attention for network management have grown commensurately. While the issue is not likely to be a complex problem (many different models for the management of Federal research facilities already exist), some attention needs to be given to the administrative arrangements for a full-scale network.

IV. Action:

If a national network is deemed to be a worthwhile effort, the issues listed above suggest that someone (NSF, NAS, etc.) should first be charged with the responsibility of developing a feasibility study and plan that addresses these problems, plus any others that might arise. This planning effort should draw heavily on the experience gained by the Computer Science Section in its CSNET effort and by both the Computer Science Section and the Information Science Division in their national networking research. Outside scientists from a wide variety of disciplines should also have a heavy role in the planning, possibly in the form of an advisory panel.

NSF might also be directed to formally explore with DARPA the possibility of transfer or shared use of ARPANET as one possible facility.

NSF ACTIVITIES RELATED TO A NATIONAL SCIENCE COMPUTER NETWORK

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Summary

The National Science Foundation is mounting an expanded research program which could lead to the development of a National Science Computer Network linking universities, colleges and other institutions in support of research and education. This expanded research program is focusing on the many issues and considerations related to developing the resource-sharing potential of such a network for the major functions of research and educational computing and science information services. Foundation-sponsored research, developmental activities and special studies have been underway for several years in regard to computer-based resources and facilities for research and education, associated user services and network technology. This paper provides an overview of several of these projects as they relate to the many dimensions and facets of needs and desirability, planning, establishing, operating and evaluating a National Science Computer Network.

Introduction

The National Science Foundation has for many years been sponsoring activities to improve the use of computers and computer-based resources in research, education and in science information services. The uplink of recent developments in computer and communications technology is adding a new dimension to these efforts. Computer communication networks which are national in scope are in being, and the establishment of a National Science Computer Network linking users at academic and other institutions to specialized resources for computing and science information services would have profound implications for resource sharing in research and education.

In some cases, a network would facilitate the pooling of resources, including the collaboration of researchers independent of institutional affiliation, the establishing of facilities for shared use, which might be beyond the financial reach of any individual institution. In other instances, special computer languages, computational algorithms, data banks and other computer-related developments which are created in a local environment could have direct and immediate application for others in the research and educational community. In particular, such a network would offer possibilities for a much closer integration of computing and science information services than has been effected previously.

The problems of creating and utilizing a National Science Computer Network for research and educational computing and science information services are not only in technical areas but very much in organizational, political and economic areas as well. Issues and considerations that arise immediately are those of specialized resources and services, common interest user groups, network management, impact on campus computing centers, network financing, and the overall need and desirability.

The Foundation's Office of Computing Activities (OCA) and the Office of Science Information Service (OSIS) are cooperating in mounting an expanded research program relative to a National Science Computer Network. A comprehensive and interrelated set of project activities is envisioned to explore and evaluate the many dimensions and facets involved. Research, development and special studies in connection with resource sharing, user services and network technology are already underway, and this paper provides an overview of several projects recently sponsored by the NSF as they relate to this expanded research program.

Research Resources

One of the arguments for a National Science Computer Network is that specialized facilities and resources could be available for given disciplines or classes of computations. The National Center for Atmospheric Research (NCAR) with its large-scale computing facility is well known. Although the principal use of the computing facility is in support of NCAR's own research, the facility is available to academic researchers with appropriate research problems. The Inter-University Consortium for Political Research, with a membership of approximately 150 institutions, has both data and programs available. The Chemical Abstracts Service of the American Chemical Society is a computer-based science information resource which is also nationwide in scope.

Recent Foundation-supported projects for which a National Science Computer Network would have special implications include: The Computer Research Center for Economics and Management Science of the National Bureau of Economic Research, a study of a national laboratory for theoretical chemistry, and a study of a national center/network for computational research on

guage. Another project for which the Network might have a long-range benefit is the Clearinghouse and Laboratory for Census Data, although its establishment was not predicted on the emergence of network facilities. These four projects are described briefly in the following.

Computer Research Center for Economics and Management Science

The Computer Research Center for Economics and Management Science of the National Bureau of Economic Research is a major disciplinary center established with support from the Division of Social Sciences and Statistics. The Center was conceived to stimulate new computational technology for research in the disciplines of economics and management science. Advanced research computational techniques and systems are created and distributed to the research community. A key element in the organizational structure of this Center is a Policy and Operations Committee. Its membership includes academic scientists with research interests in economics, management science, computer science, mathematics and statistics. The Center is designed to attract researchers in these fields and in computer science from universities and colleges, Government, nonprofit institutions, and the private sector. Researchers, both in residence at the Center and in remote locations, are participating in the research effort. The development of a National Science Computer Network would add materially to these efforts.

Study of a National Laboratory for Theoretical Chemistry

The National Academy of Sciences-National Research Council is conducting a study of the feasibility of a national laboratory for theoretical chemistry as a project supported by the OCA and the Chemistry Division of the Division of Mathematical and Physical Sciences. The study is being carried out by a committee of approximately 30 individuals selected to include scientists from diverse areas of research, computer scientists, mathematicians, and representatives from other relevant scientific disciplines. The main tasks of the committee are to identify important chemical problems amenable to solution at such a laboratory, identify special problems of computer science involved, and to explore and characterize the structure and operation of such a facility. In addition to these substantive matters, the committee is concerned also with the broader questions of the impact of such a laboratory on university computing centers, development of computer networks, computer program exchange, and interfacing the laboratory with the scientific community.

Study of a Center/Network for Computational Research on Language

A study is being conducted at the University of Illinois with support from OCA and the Division of Social Sciences to develop the concept of a national center/network as an innovative approach for the rapidly based interdisciplinary area of computational research on language. The optimal organization structures for any such center/network are being studied as

well as the critical questions of priorities and implications as to areas of research and methodologies to be employed. A wide range of individuals with respect to geography, institutions, and disciplines are participating in the effort. A published study of the project activities is forthcoming.

Clearinghouse and Laboratory for Census Data

Another resource with national import is the recently established Clearinghouse and Laboratory for Census Data (CLCD) supported by the Division of Social Systems and Human Resources. The CLCD is operated by DUALabs under contract with the Center for Research Libraries. Assistance to researchers includes census use orientation and training, research proposal review and cost forecasts. Training programs are provided, needed computer software is developed, and a central information source is maintained of selected census research projects and of available data files. The activities of the CLCD are augmented through the cooperation of other organizations to whom the programs, catalogs, registers and materials of the CLCD are made available.

Research Services and Uses

The development of user-oriented services for network application is fundamental to a viable National Science Computer Network. Although the research resources described in the previous section would all have associated service functions, the development of some kinds of services and facilities need not be associated with a major regional or national resource. Several projects are highlighted which are illustrative of possible kinds of research services and uses within a Network.

Software Development for Theoretical Chemistry

A discipline-oriented software development project in theoretical chemistry is underway with OCA support at the University of Utah under the direction of Dr. Frank E. Harris. The software is being designed in a way to facilitate the use of theoretical calculations by workers in all fields of chemistry including those not expert either in details of the theoretical analysis or in digital computation. The project is also novel in that it provides for consultation regarding distributed software, pilot use of remote computing facilities, and preliminary development aiming toward eventual public use of computer networks. The use of the ARPA Network will be explored in support of these project activities.

Quantum Chemistry Program Exchange

Another kind of prototype network service is that represented by the Quantum Chemistry Program Exchange (QCPE) at Indiana University. Members of the QCPE submit programs together with documentation and test data and outputs. The QCPE provides a uniform testing environment for the programs, completes the documentation and makes the availability of the program packages known through appropriate newsletters and other

reports. Foundation support has been provided by the Chemistry Section of the Division of Mathematical and Physical Sciences and OCA. The operation of the QCPE is expected to be eventually self-sustaining on the basis of membership and user charges. The programs being developed under the theoretical chemistry software project noted previously will be distributed through the QCPE.

Hierarchical Computing

Hierarchical computing in which access is provided to a range of levels of computing and information services in support of research or instruction relates directly to resource sharing via a national network. In one OCA-supported project in hierarchical computing, the use of minicomputers in scientific experiments may be improved as a result of a prototype interfacing support system under development at the University of Chicago. The purpose of the project is to provide the means for enhancing scientific methodology for experimental research. This experimental system consists of support for the researcher at three levels: (1) a monitoring subsystem to which minicomputers can be interfaced, (2) a subsystem providing high-level support services such as compilation and bulk data storage, and (3) a subsystem which would facilitate access to major computing facilities on a national network.

Use of Remote Graphics

One of the projects supported by OCA which can be viewed as a prototype of network use in research is being conducted by Dr. D. Raj Reddy at Carnegie-Mellon University. The primary long-term objective of this research is to develop geometric models of structure and organization of the neural networks of the swimmeret system of the lobster. The functional requirements for the research computer system include getting visual data into the computer, reducing it to compact form, displaying the resulting three-dimensional structure on a CRT display to permit researchers to formulate theories, and devise algorithms for comparison of neural networks. One expectation of the project is that the feasibility and utility of such a network modeling system can be demonstrated using an Evansutherland LDS1 graphics system remotely through CRT facilities linked to the ARPA Network at Carnegie-Mellon University.

Use of Remote Data Banks through "Intelligent" Terminals

The use of a large-scale computing facility with specialized data banks and program library through "intelligent" remote display terminals is being addressed in a collaborative project involving Brookhaven National Laboratory and Texas A&M University. A "Protein Data Bank" has been established at Brookhaven National Laboratory in cooperation with the Crystallographic Data Center in Cambridge, England. The prime purpose of such a computer-based, macromolecular structure library is to facilitate dissemination of raw or refined data in a variety of forms to permit users to ask easily chemically interesting questions. One goal of the project is to develop a crystallographic computing system which provides to the researcher in an

individual laboratory all the computing facilities necessary for molecular structure determination. A relatively inexpensive minicomputer-based display facility has been constructed which is capable of three-dimensional graphics and interactive use. In addition to the developmental activities supported by OCA, the system will be refined through the experiences of a third group in a remotely-located research laboratory.

Networking Activities Relating to Science Information Systems

The Foundation's Office of Science Information Service has also been supporting system development efforts which are primarily based in the scientific professional societies and the university sector. The society-based systems produce the information bank (i.e., abstracts and indexes of the world's scientific literature) and supply tapes recording its content. The university-centered systems provide the distribution outlets to the user community.

The problems which will pose the major obstacles to successful efforts in networking of information resources are not judged to be primarily technical in nature. The areas which require immediate attention and where it is intended that initial support be focused are concerned with administration, user requirements, economics, and legal matters. For example, the optimum mechanism for the administration of a network which may consist of a loose consortium of universities cannot at this time be specified with any degree of precision. When this problem is compounded by the factors of geographic dispersion and regional interests on a nationwide basis, the ramifications of this concern only begin to emerge.

Thus, the communication system of science and technology is a melange of procedures, media, production techniques, services, centers, and people. The system has evolved by way of necessity and expediency, and in its current stage of development exhibits many different types and levels of complex interactions. Many services and institutions, which constitute centers of experience in various segments of the information transfer community, are operational at the present time, and these will certainly function as nodes in whatever network will evolve. Such a network undoubtedly will be evolutionary, in the sense that it will develop as circumstances permit, rather than being systems engineered a priori. The present resources in operational components of the network represent an investment too large to scrap in favor of an optimal design even if it were possible to design the optimal network. Because of this, it becomes necessary to plan a course of action flexible enough to accommodate different strengths and relationships among the existing nodes which include the tape suppliers and publishers, as well as the distribution centers and libraries.

A natural outgrowth of these efforts has been a start toward embryonic networking activities. Moreover, the costs associated with system development and operation are rapidly making it clear that such activities are likely to become an economic necessity in the future. Much work remains to be done to foster cooperative arrangements, but much has already been accomplished. The interface of OSIS-supported information

tems with OCA-supported regional computing networks projects at the University of Georgia and Lehigh University is illustrative of these cooperative efforts. The following are examples of current activities:

University of Georgia

The system which is under development at the University of Georgia will provide twenty-six Georgia universities and colleges access to a broadly-based information service via the OCA-supported regional computing network. It also services many external users, including Federal agencies. It is a very broadly-based system, but the primary focus is in the areas of chemistry and the biological sciences. The system offers batch-mode current awareness searches based on the concept of selective dissemination of information as well as in-depth retrospective searching of large information bases such as those produced by the Chemical Abstracts Service of the American Chemical Society.

University of California at Los Angeles

The system which is under development at UCLA will eventually service the nine campuses of the University of California System. They currently plan to experiment with providing current awareness searches on the ARPA Network to users at one of the nearby universities that is also on the Network. While the system presently employs information specialists at the computer interface for batch-mode service, there will also be an interactive mode whereby queries can be made on any of forty rapid response terminals which are strategically located around the UCLA campus.

Lehigh University

The on-line, interactive system at Lehigh University permits the user to query full text articles and abstracts in a natural language mode for current documents via remote CRT terminals. This service primarily reflects the demands of a user group which is comprised mostly of engineers in the various research centers at Lehigh University. In addition, it provides information services to seven other academic institutions in the Lehigh Valley Regional Computing Network whose development was supported by OCA. They are also conducting an information networking experiment with the University of Georgia via a phone line, dataset, and VAC Uniscope 100 CRT terminal. The purpose of this experiment is to provide an operational service as well as to establish key roles for future network nodes.

For example, the Lehigh system does not have extensive document files, but it does possess considerable software for full text analysis, automatic document characterization, file generation, data base construction, and interactive search negotiation. It is conceivable that Lehigh as a network node would maintain no document files but would instead act as an interface message processor, accepting requests from remote terminals, negotiating them, and dispatching them for execution to other nodes. It could also act as a network monitor for information flow.

Georgia, on the other hand, has the most extensive data files of any university information system, and the determination of its role in the network will be of primary importance. Clearly, all will

benefit from networking interactions provided the allocation of functions occurs in an optimum fashion.

The Environmental Protection Agency

The Environmental Protection Agency has just announced a program of cooperation with science information centers developed through grants from OSIS. This cooperative agreement was undertaken with the firm conviction that existing systems and services should be used whenever possible, rather than generating new ones.

Under this new program the information service centers of three universities will be coordinated for EPA use. Lehigh University has been selected to provide on-line services, the University of Georgia will be responsible for batch and retrospective services, and Ohio State University will produce selected SDI programs on a trial basis. This program will permit the Environmental Protection Agency to have access to over twenty-five data bases, while determining usage requirements of the various files and services.

This arrangement will serve a network of some forty EPA libraries and information centers, with the library at EPA's National Environmental Research Center in Cincinnati, Ohio, designated as access point to the information centers. A series of terminals will soon be installed in Cincinnati to provide on-line and batch search and retrieval capabilities. In this manner each EPA facility will be able to search over two million documents and receive a printout with a minimum of delay. Eventually this network will be expanded to improve data base coverage and to provide additional services to EPA personnel interested in searching data bases of environmentally-oriented literature.

Georgia/Lehigh

A simulation study of an information dissemination network is now being supported by a joint grant to the University of Georgia and Lehigh University. Alternative configurations and modes of operation for a computer-based information dissemination network will be studied through the use of simulation and mathematical modeling techniques. The operational characteristics of the network system and associated costs will be examined with respect to time and anticipated growth rates. Computer hardware requirements, communications media, anticipated usage, and manpower requirements will be taken into consideration in design of the model. Several types of dissemination centers and functions for nodes within the network will be studied. The technical plan calls for the development of an adequate model of an information dissemination network and the simulation of network activity via model manipulation. Emphasis will be placed on design criteria assumed in the model and the alternative configurations derived during the course of the simulation model as well as the administrative problems associated with the implementation of such a network.

Instructional Uses

One aspect of the National Science Computer Network initiative is to explore the extent to which such network could be used in the support of instructional computing on an individual campus. The NSF has already supported activities which have addressed many of the problems involved. The Institutional Computing Services Program, for example, provided support not only for the development of the campus computer center but also for facilities to be shared among institutions. The OCA Regional Cooperative Computing Activities Program also provided support for projects to explore the development of shared computer resources for educational use. The first regional projects under this program were established in 1968. Approximately 30 regional computing projects have been supported involving about 300 institutions of higher education.

Projects have been initiated to study the problems of computer-based curricular developments, documentation and transfer. One of these projects which would have a bearing on the use of a nationwide computer network for instructional support is described below:

CONDUIT Project

Five regional computer networks are collaborating with OCA support to test the feasibility of transporting computer-based materials for the purpose of enhancing curricular development in higher education. The participants are: Dartmouth College, the North Carolina Educational Computing Service, Oregon State University, and the Universities of Iowa and Texas. The experiment which goes under the name of "CONDUIT" involves forming a central organization and staff at the five regional networks to transport curricular units; testing the transported materials in classrooms in each network; producing a catalog (with standards for material quality and transportability) of curricular materials for national dissemination; and documenting the feasibility study as to procedures, cost considerations (including billing and accounting procedures, user feedback, and adequacy of the process).

Software Testing and Distribution

The National Science Computer Network initiative has special implications for the analysis, testing and distribution of computer programs. A nationwide network could do much to facilitate the transfer of programs from machine to machine and at the same time reduce the need for doing so. It is envisioned, for example, that some sites on a network could assume responsibility for maintaining certain software. This is the case, for example, with some of the systems being developed at the Computer Research Center for Economics and Management Science. OCA and the Division of Engineering are already cooperating in exploring approaches to improving the quality of engineering software. The special attention given by the NSF to problems of improving the quality of mathematical software for research use is highlighted by two projects which have implications for a National Science Computer Network.

National Activity to Test Software

The National Activity to Test Software (NATS) is being conducted with OCA support by Argonne National Laboratory, the University of Texas and Stanford University in cooperation with various field test sites. This project is a collaborative prototype effort to evaluate, certify and disseminate mathematical software. Selected mathematical software, including a set of special function routines and a package of matrix eigensystem routines, is tested, first at the three principal institutions and then at 16 field test sites. The certified products are distributed by the Argonne Code Center. A key aspect of the project is the emerging of a collaborative testing methodology.

Study of Alternative Approaches to Testing and Distributing Software

In a related project supported by OCA, the University of Colorado and Argonne National Laboratory are collaborating in a study to explore approaches to the problems of making high quality mathematical software readily available to the computing community. The study is examining the possible roles of academic institutions, the National Laboratories, the National Bureau of Standards, and the private sector. It is intended that the study produce source material and a blueprint for action. A National Science Computer Network could have special relevance for these efforts.

Network Technology

The OCA and the Division of Engineering have supported several projects which are leading to new developments in computer communications for networks. Two projects supported by OCA which have a special bearing on advancing network technology are the MERIT project in Michigan and the Distributed Computer System being developed at the University of California at Irvine.

The MERIT Computer Network

The MERIT Computer Network, Michigan's Inter-university Computer Network, is an experimental project to link computing systems at the University of Michigan, Michigan State University, and Wayne State University for the purpose of enabling the three institutions to share and extend their computing resources. The MERIT project is concerned not only with the technical problems of computer-to-computer communications but also with the political, organizational and economic problems of sharing major resources. Special emphasis is being given to developing the user services to allow students, faculty and staff of these three universities to use the computing resources of all three systems. The development and testing stages involve Michigan, Michigan State and Wayne State only; however, the MERIT Network does serve as a pilot project to be analyzed in connection with exploring the resource-sharing potential of a nationwide computer network.

Distributed Computer System

An experimental computer network called the Distributed Computer System is being developed and constructed at the University of California at Irvine. This research project is designed to explore those issues in distributed architecture useful in serving small and medium scale computers which are appearing in large numbers on university campuses. Communications within the system is based on a digital ring topology in which computers are interfaced. The communication protocol is unusual in that messages are addressed directly to the location of the receiver but by means of the name of the receiver. Aims of the project are: low cost, reliability, easy addition of new services, modest initial costs and low incremental expansion costs. Such a network could also be considered as a subnetwork in a hierarchy including access to a national network.

National Bureau of Standards Activities Relative to a National Science Computer Network

The Center for Computer Sciences and Technology at the National Bureau of Standards is carrying out studies and other special tasks with OCA and OSIS support in connection with the Foundation's Network initiative. The current efforts focus on the areas of network communication technology and network management and operation and computerized information systems as related to this emerging Foundation thrust.

Alternative technological approaches are being evaluated by the National Bureau of Standards within a framework of possible network structures and functional requirements and constraints for an eventual National Science Computer Network. Included in this effort is a compilation of all relevant literature on network technology. Another thrust of the Bureau's efforts includes considerations of network management. This function must be emphasized strongly in achieving a viable network operation. The numerous tasks associated with setting up and operating a national resource-sharing network are being identified, and an evaluation is being made of alternative strategies for implementing and operating a network utilizing various managerial structures.

Criteria are also being developed for measuring the performance of the proposed Network. Included, for example, is a detailed measurement plan containing accounting mechanisms to satisfy overall management objectives. Another important part of the current effort is the development of a set of terminology to support adequately communication among network planners, designers, implementers and users. This terminology will be based on state-of-the-art usage of terms in the computer networking area.

Implications for Colleges and Universities

The establishment of a National Science Computer Network would provide new options to academic institutions for computing and information services, but would also raise organizational, political, and financial problems. Several studies are in progress which are addressing some of the issues and considerations involved. The discussion of activities relating to

science information services made note of some of these considerations. Three other studies are also highlighted: A study by the University of Denver is addressing the overall problem of managing and financing academic computing centers; the University of Southern California, California Institute of Technology, and the University of California at Los Angeles are exploring new approaches to computer resource sharing, and the University of California is examining the role and impact of computer and information sharing for a multi-campus institution within the context of a national network.

Alternative Approaches to the Management and Financing of Academic Computing Centers

The University of Denver is conducting a study of alternative approaches to the management and financing of academic computing centers. The purpose of the study is to determine how to optimize insofar as possible computing capabilities and operations on individual college and university campuses, and to identify conflicts between this optimization and established institutional goals, policies and operations. The sharing of facilities by means of a network is one possible alternative. Case studies will be developed in depth for selected alternatives reflecting experiences of particular institutions in responding to specific problem areas and in the effects and consequences of such actions in that institution. Conclusions of this study should be applicable to most four-year institutions of higher learning in the United States and should assist college and university administrations in dealing with the complex and growing problems of the role, management, and financing of the computing center on campus.

Computer Resource Sharing

The University of Southern California, California Institute of Technology, and the University of California at Los Angeles are collaborating on a feasibility study of computer resource sharing. This study is addressing questions of sharing computer resources within the framework of a nationwide network with special emphasis on implications for a subnetwork of institutions as these three institutions might represent. Areas of concern include responsibilities of the network to institutions and, conversely; management considerations relating to subnetworks; staffing at local and network levels for optimum use of network resources; alternative strategies for coping with risks and liabilities of sharing network resources; and approaches to network financing.

Network Implications for a Multi-campus University

The University of California is conducting a study on the academic, administrative, and economic implications of a sophisticated data communication network on a decentralized, multi-campus university. The results of the study are expected to have applicability not only to the University of California but also to other educational organizations or federations in evaluating alternative network developments.

The issues and considerations being examined

1 into the general categories of (1) the impact of increased access to both internal and external services on internal and external users and suppliers; (2) the requirements of instruction, research, administration, hospital and library computing and the effects on them of various current network technologies; (3) the interconnection of diverse networks and the impact of interconnection on all participants; (4) the isolation of technical and administrative criteria to define a viable network.

Perspective on the NSF Network Initiative

The preceding discussion provides an overview of one of the projects supported by the Foundation which is intended to explore the resource-sharing potential of a nationwide computer network. There are, of course, many dimensions and facets to such a thrust and the Foundation's expanded research program relative to a National Science Computer Network is designed to permit exploration and evaluations of issues and considerations involved.

Guidelines are anticipated in regard to other activities including a proposed trial National Science Computer Network to support these activities. The projects highlighted in this paper should, however, be indicative of the scope of this Foundation initiative.

Reference

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A National Network for Scientific Research

I. History of NSF involvement:

From the earliest days, computational scientists have thought about ways to share expensive computing resources, for their needs always seemed to outstrip the ability of their local institutions to provide for them. As a result, NSF has had a role in networking that dates back to the Computer Facilities Program of the '60s. At that time, large grants were made to universities for purchase and initial operation of research computers. A few of those grants supported what were, at the time, innovative experiments in sharing resources -- for example, the Triangle Universities Computer Center that served North Carolina, N.C. State, and Duke University, and the MERIT network in Michigan that shared the facilities of Michigan, Michigan State, and Wayne State University.

At the same time, the Office of Science Information Services (OSIS), along with the Office of Education, were funding projects exploring library automation and automated bibliographic services. These projects, as they grew beyond simple experiments, led eventually to developing regional and national networks for sharing and interchange.

In 1967, NSF initiated a Regional Centers Program to support experiments in regional sharing of computer facilities. That program was focused principally on educational uses, and explored the use of networking to provide computer access to small, undergraduate schools. Some of those projects seeded regional computer sharing programs that exist today, for example, in North Carolina and the New England region.

In the early 1970's, NSF began considering the development of a national scientific computing network. Concern in some circles that NSF was about to build and operate a civilian version of ARPAnet, led to a downscaling of their plans to a more modest program of support for "Research Relative to a National Science Computer Network." (See attachment A, an article written by D.D. Aufenkamp, the program director, in 1972.) In that program, jointly run by Computer Science (then, the Office of Computing Activities) and the Information Science Division (then OSIS), a number of large projects were initiated. It was during that period that EDUCOM began to arise as a major player in the University resource-sharing business, and it was through a sequence of NSF grants to EDUCOM that a number of institutional, economic, and managerial barriers to networking were uncovered and analyzed. EDUCOM's experience with these research projects led them to form EDUNET as an attempt to cope with some of these problems.

II. Current Activities:NSF

Most recently, the Computer Science Section in NSF has concentrated on using what was learned in the networking research program to develop a national network among computer scientists. The network, called CSNET, has